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August 1996

GEOCODED IMAGERY PRODUCTION SYSTEM

Synectics Corporation

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The Environmental Research Institute of Michigan (ERIM) successfully designed, configured, implemented, documented, and tested a Geocoded Imagery Production System (GIPS) for the 480th Intelligence Group (IG), Langley Air Force Base, Virginia. The system is composed of commercial off-the-shelf (COTS) hardware components, COTS software packages, and nondevelopmental software packages designed to provide the production environment and tracking tools necessary to process and deliver ARC Digital Raster Imagery (ADRI) products. The system generates products compliant with the Broad Area ADRI Product Specification and the ADRI Format Specification, each dated 24 July 1992.
The U.S. Air force established the ADRI program to provide the utility of an unclassified, broad area, current database of imagery to support mission planning. The ADRI image databases are used in mission planning and theater battle management systems as an image backdrop to assist mission profile development, a means to provide geopositioning information for navigation and target area acquisition, and a real-world scene for perspective view generation and mission preview. The 480th IG has the responsibility for the production of ADRI for the Air Combat Command.

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ACRONYMS

ADRI	ARC Digital Raster Imagery
AFB	Air Force Base
APPS	Analytical Point Positioning System
CCT	Computer Compatible Tape
CD-ROM	Compact Disk-Read Only Memory
COTS	Commercial Off-The-Shelf
DMA	Defense Mapping Agency
DTED	Digital Terrain Elevation Data
EOD	Erasable Optical Disk
ERIM	Environmental Research Institute of Michigan
ERIPS	ERIM Remotely-Sensed Image Processing System
GCP	Ground Control Point
GIPS	Geocoded Imagery Production System
GIU	Geo-Image Unit
HRV	High Resolution Visual
IG	Intelligence Group
MCP	Map Control Point
SCSI	Small Computer System Interface
SOW	Statement of Work
SPOT	Satellite Pour d'Observation de la Terre
SPR	System Problem Report
USAF	U.S. Air Force
ZDR	Zone Distribution Rectangles

1.0 EXECUTIVE SUMMARY

The Environmental Research Institute of Michigan (ERIM) successfully designed, configured, implemented, documented, and tested a Geocoded Imagery Production System (GIPS) for the 480th Intelligence Group (IG), Langley Air Force Base (AFB), Virginia. The system is composed of commercial off-the-shelf (COTS) hardware components, COTS software packages, and nondevelopmental software packages designed to provide the production environment and tracking tools necessary to process and deliver ARC Digital Raster Imagery (ADRI) products. The system generates products compliant with the Broad Area ADRI Product and ADRI Format specifications dated 24 July 1992 (see Section 10, References).

Synectics Corporation was the prime contractor for this project. They procured the hardware and the commercial software packages.

The project started on Wednesday, 7 September 1994, and the system was installed and accepted on Wednesday, 22 February 1995.

As a result of this project, ERIM was awarded a follow-on activity. As part of that activity, we are providing operator and supervisor instruction and support for the operation of the GIPS at the 480th IG. ERIM is also augmenting the GIPS with additional functionality.

2.0 OVERVIEW

2.1 BACKGROUND

The U.S. Air Force (USAF) established the ARC Digital Raster Imagery (ADRI) program in 1990 in recognition of the utility of an unclassified, broad area, current database of imagery to support mission planning. The ADRI image databases are used in mission planning and theater battle management systems as an image backdrop to assist mission profile development, a means to provide geopositioning information for navigation and target area acquisition, and a real-world scene for perspective view generation and mission preview. The 480th Intelligence Group (IG) has the responsibility for the production of ADRI for the Air Combat Command.

This final report covers the work performed by ERIM on Phase I of the Geocoded Imagery Production System (GIPS). GIPS consisted of four major activities:

- System Engineering (Section 3)
- Software Engineering (Section 4)
- Testing and Documentation (Section 5)
- Management (Section 6)

Each activity contains a section that summarizes the work accomplished and the information gained and is followed by a section that details pertinent observations and lessons learned. The four activities are followed by:

- Potential Process Improvements and Procedural Adjustments (Section 7)
- Follow-on Actions (Section 8)

2.2 PROJECT SCHEDULE

2.2.1 Description

The original schedule, shown in Figure 1, was based on a 15 August 1994 start date and an on-site acceptance test date of 15 January 1995, for a project duration of 22 weeks.

ERIM received notification of the project start on Wednesday, 7 September 1994. The on-site acceptance test was successfully completed on 22 February 1995, resulting in a project duration of 24 weeks. The two additional weeks required to deliver the system were due primarily to the problems encountered during the port of the ADRI Production Database System to ORACLE V6 and the port of the ADRI software to Solaris 2.3. The actual schedule is show in Figure 2.

2.2.2 Lessons Learned

Several contractual delays resulted in the project not starting until 7 September 1995. The uncertainties in the start date caused delays in staffing during the initial weeks of the project. This could have been minimized if a two to four week ramp-up activity had been scheduled into the project.

The original schedule should have included at least two weeks of slack to allow for unexpected problems such as those that were encountered.

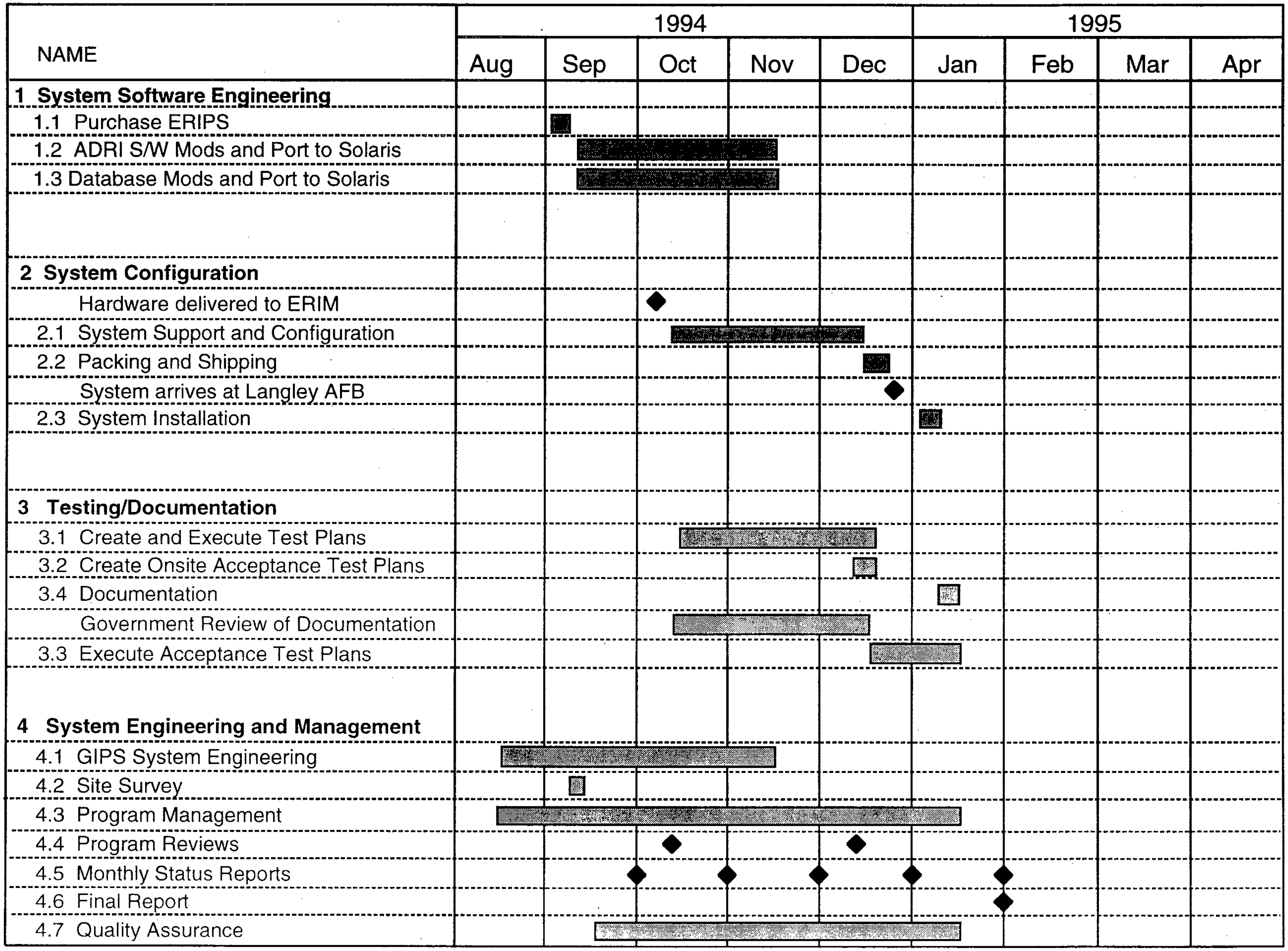

Figure 1. Proposed Schedule

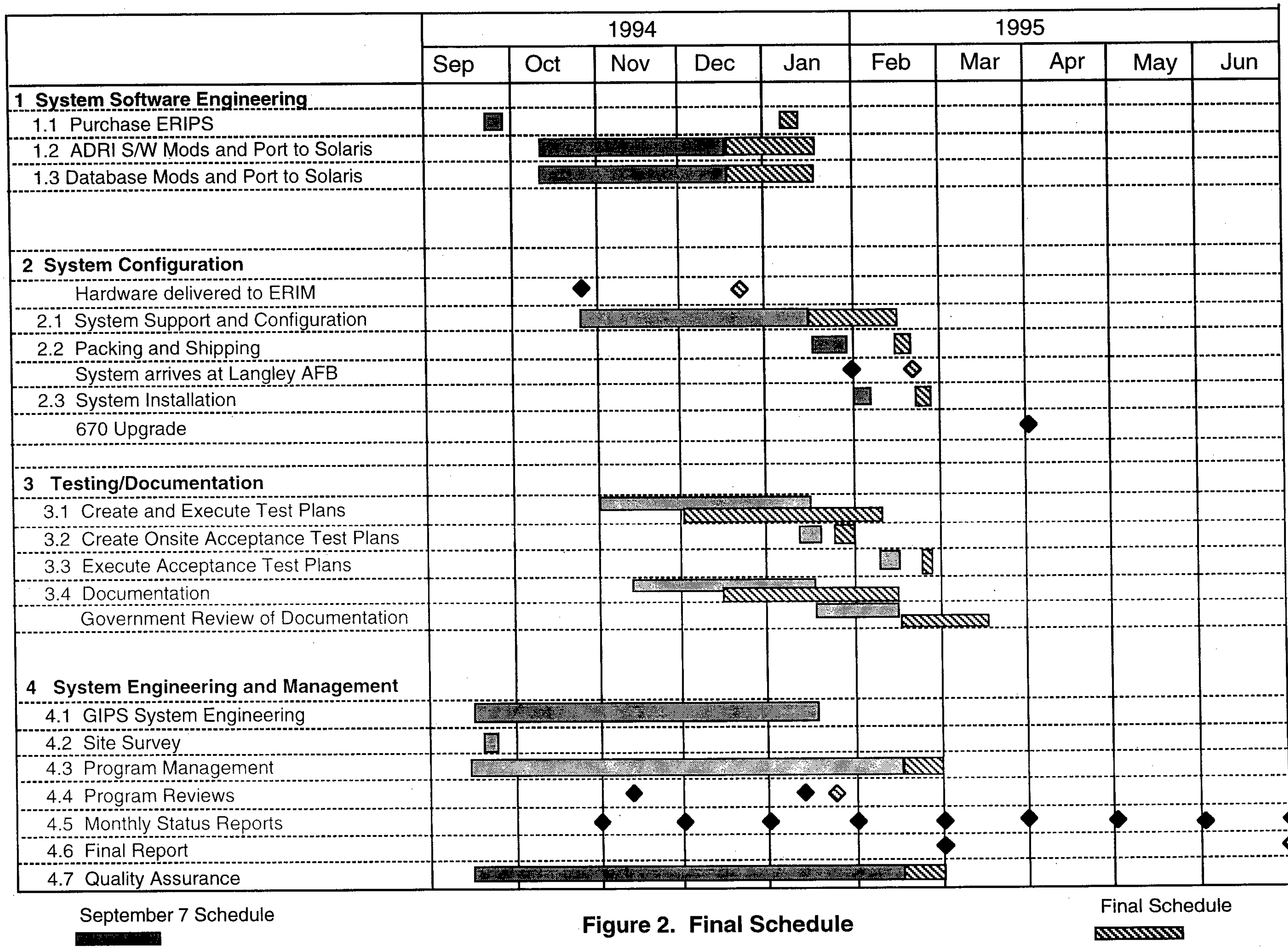

Figure 2. Final Schedule

3.0 SYSTEM ENGINEERING

3.1 GIPS SYSTEM ENGINEERING

3.1.1 Description

We conducted all system engineering tasks required to design and integrate the GIPS into the production environment at the 480th IG. This activity included a requirements definition and review and a site survey. We defined and documented the external and internal interface requirements as part of the Interface Control Document and as part of the Installation Plan.

On 22 and 23 September, ERIM conducted a site survey of the 480th facility at Langley Air Force Base (AFB). The purpose of the survey was to identify any site-specific requirements that were necessary for the intended system operation.

The site survey resulted in the identification of a number of issues, including:

- How and when the Government would upgrade the 480th's existing Sun 670 from Solaris 1.1 to Solaris 2.3,
- Furniture and work space layouts,
- Access to the facilities,
- Power requirements,
- Security considerations, and
- System networking.

The site survey was followed by a two-day visit in October. Although this visit was not in the original proposed effort, it proved to be very beneficial. The purpose of the trip was to further familiarize us with the 480th's existing production capability, the operators, and their procedures.

In order to better manage and resolve problems, a system problem report (SPR) system was established and used.

3.1.2 Lessons Learned

The site survey and the follow-on visit were very beneficial. They helped establish a good working relationship between ERIM and the 480th. The site survey accomplished its basic goal: early identification and resolution of issues in order to allow a successful installation and integration of the system at the 480th.

Unfortunately, during the course of the project we were never able to satisfactorily address the issue of the Government's upgrade of the 480th's existing Sun 670, even though it was identified and worked early in the project. The Sun 670 was eventually upgraded in the field with ERIM's on-site assistance almost one month after the planned completion of the project and in parallel with the follow-on training activity.

3.2 SYSTEM SUPPORT AND CONFIGURATION

3.2.1 Description

Synectics, the prime contractor, procured the hardware and commercial software. It was shipped by the vendors directly to ERIM's facility in Ann Arbor, Michigan. ERIM configured the hardware and the software.

Overall, this arrangement proved workable. It required additional communication which, at times, included ERIM's technical personnel, Synectics' technical personnel, Synectics' purchasing department, and the vendors. With this arrangement it took longer to purchase the hardware and resulted in some additional confusion and mistakes. Most of the mistakes could be attributed to the fact that ERIM did not specify some pieces of the hardware as precisely as required, for instance, Small Computer System Interface (SCSI) cable connectors and cable lengths.

The system configuration activities included installing and configuring all commercial off-the-shelf (COTS) packages, including: Solaris 2.3, ORACLE, ARC/INFO, Motif, SPARCworks and SPARCworks C compiler. It also included configuring and installing all hardware components.

The system support activity included backing up the system, performing system administration, identifying and installing patches to the Solaris 2.3 operating system, and maintaining the hardware.

As part of the system configuration effort, ERIM prepopulated the ADRI database with the metadata describing the current USAF inventory of Satellite Pour d'Observation de la Terre (SPOT) scenes, ground control points, ADRI Zone Distribution Rectangles (ZDR), and ADRI Volumes. Miscellaneous database tables such as the Country_Code Table were also populated.

3.2.2 Lessons Learned

The approach used to procure the hardware and software demonstrated that the purchase and integration of the equipment by separate contractors can be done successfully. We wish to note that it does require additional communications and precise specifications.

3.3 HARDWARE CONFIGURATION

3.3.1 Description

A four-workstation hardware configuration was specified to satisfy the minimum production requirements of the GIPS, which are eight SPOT scenes per day using two, eight-hour shifts. The hardware configuration made use of Government-furnished hardware already present at the 480th IG and listed in Table 1. Additional hardware, identified in Table 2, was procured by Synectics Corporation to complete the GIPS configuration.

Table 1. Government-Furnished Hardware

Hardware	Quantity
Sun 670 MP, 130-Megabyte RAM, 2 SCSI Buses	1
Sun 1.3-Gigabyte External Disk Drive	4
Sony Compact Disk-Read Only Memory (CD-ROM) Reader	1
8-mm Tape Drive (Exabyte EXB-8200)	2
1/2 inch 9-Track Tape Drive (HP-88780)	1

Table 2. New Hardware

Hardware	Quantity
Sun Sparc 20/502 Dual 50-MHz Processors, 20 inch Color, Internal 1.05-Gigabyte Disk Drive, 32-Megabyte RAM	3
RAM Additional 64-Megabyte Single Package	3
RasterFLEX-HR Single SBUS Display Board	4
Seagate Elite 9 External Disk Drive (9 Gigabyte)	3
Contemporary Cybernetics Erasable Optical Drive	4
8-bit X-Windows Terminal (NCD19C)	1
Laser Printer (QMS 860)	1
Continuous Tone Thermal Printer (Alden 9315CTP)	1
10 Based-T 8-Port Micro Hub	1
8-mm Tape Drive (Exabyte EXB-8500)	1
3.5-inch Floppy Drive	3
Internal CD-ROM Drive	3

Originally, the ADRI Production Database System was to reside on the existing Sun 670, and most of the SPOT and Digital Terrain Elevation Data (DTED) data were to be loaded on that system. Once we realized that the Sun 670 could not be upgraded until the three new systems were operational and staffed with trained operators, we revised the system architecture as shown in Figure 3.

As the hardware was received it was inventoried and entered into ERIM's Government-approved property inventory system. When it came time to ship the equipment, we used the property inventory system to help generate the shipping lists.

3.3.2 Explanatory Notes and Lessons Learned

3.3.2.1 Elite-9 Disk Drives

At the time of the 14 November 1995 program review, we had indications from the vendor that the Elite-9 disk drives might not be delivered until January 1995, which would have caused major delays in the project. Consideration was given to purchasing pairs of Barracuda-4 disk drives as an alternative to

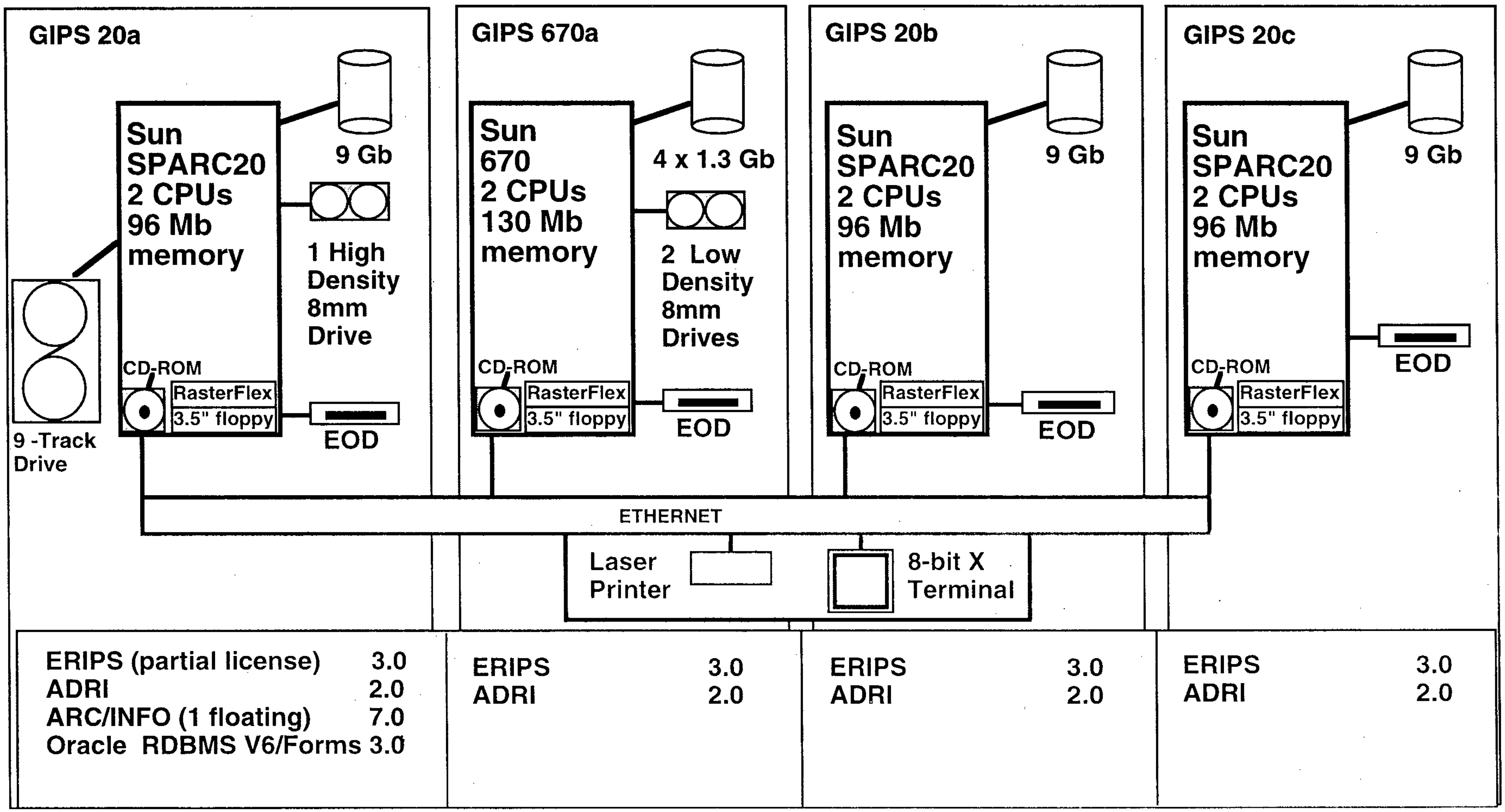

Figure 3. Revised System Architecture

the Elite-9 drives. A pair of Barracuda-4 disk drives provides 8.5 gigabytes of disk storage instead of 9 gigabytes and would have cost about $750 more than a single Elite-9. However, within two weeks of the program review we received the three Elite-9 disk drives.

3.3.2.2 Alden Continuous-Tone Thermal Printer

The proposed hardware configuration was to have included an Alden continuous-tone thermal printer. However, we found out that the vendor would not be able to provide the driver software required to interface the Alden printer with the Solaris 2.3 operating system. We had not planned on developing the driver software, and even with the vendor's assistance, we considered it far too risky to pursue.

Before undertaking the development effort, we decided to reevaluate the need for an Alden continuous-tone thermal printer. The requirement was based in part on the fact that it had been part of the Eagle Vision system. At the November program review it was decided that the Alden printer was of minimal use to the project. If an existing 480th resource could serve in place of the Alden printer, then the printer would not be purchased. In the end, the printer was neither purchased nor integrated into the system.

3.3.2.3 RasterFLEX-HR

In November, one of the four RasterFLEX-HR display cards was identified as faulty and returned for replacement to the vendor, StorNet. A replacement card was received in December. Shortly after its receipt, one of the other RasterFLEX-HR cards was identified as faulty and returned to StorNet.

The final card was received in February and delivered to the 480th IG along with the rest of the system.

We were surprised that two of the four display cards were faulty. In the past we have had no problems with these cards.

3.3.2.4 Erasable Optical Disk (EOD) Drives

The Contemporary Cybernetics erasable optical disk (EOD) drives were selected over Introl Corporation's EOD drives because the Contemporary Cybernetics EOD drives work with the generic Sun Solaris 2.3 disk device driver software. In contrast, the Introl drives require Introl's custom device driver software. We believed that using the software that came with the Sun Solaris 2.3 would be more reliable and less risky.

As expected, we did not experience any problems with the EOD drives or the Sun Solaris 2.3 disk device drivers. However, we didn't anticipate a shortcoming of using the generic disk device driver with an EOD drive. A significant characteristic of the EOD drive that is not present with a disk drive is that the media is removable. Because this characteristic is not present in a conventional disk drive, the generic disk device driver software does not detect when the operator inserts or removes the EOD media from the EOD drive. The operator issues the mount and unmount commands to the Sun Solaris 2.3 operating system to indicate the presence of the media. Unfortunately, if the operator removes the media prior to issuing the unmount command, the data on the EOD can be corrupted. We will try to minimize the likelihood of this occurring through documentation, operator orientation, and prominent warning labels on the EOD drives.

3.3.2.5 One-Half Inch 9-Track Tape Drive

Originally, the integration of the 1/2 inch 9-track tape drive was to have occurred at the 480th. However, to facilitate the smooth integration of the system, the 480th delivered their tape drive to ERIM for integration at our facility. This greatly contributed to the successful integration and testing of the overall system.

3.3.2.6 Floppy Drive and CD-ROM Drive

The original hardware specification did not explicitly state that the three new Sparc 20s should include 3.5-inch floppy drives. As a result, the systems were received at ERIM without floppy drives. In the past, the drives were included as part of Sun's standard configuration. To correct this oversight, Synectics procured three 3.5-inch floppy drives along with three internal CD-ROM drives. The CD-ROM drives were added because:

- Most commercial software is now being distributed on CD-ROMs instead of floppies,
- Most of the SPOT and DTED data that is used in the ADRI production process is distributed on CD-ROMs, and
- System disk failures are easier to recover and diagnose with a CD-ROM.

3.4 PACKING, SHIPPING, AND SYSTEM INSTALLATION

3.4.1 Description

Two weeks prior to installation, ERIM prepared an Installation Plan that was reviewed by the Government. A week prior to shipping, we did a trial pack and install exercise. As part of that exercise, the system was inspected, disconnected, inventoried, and packed in the shipping boxes. The boxes were then moved to a different location within ERIM, where the system was unpacked and installed. The exercise took an entire day.

On 20 February, after completion of an in-house acceptance test, ERIM packed and shipped the GIPS hardware to the 480th IG at Langley AFB. The packed system, 26 boxes with a total weight of approximately 925 pounds, was shipped via commercial air. It took approximately 24 hours for the system to travel from ERIM in Ann Arbor to Langley AFB.

On 21 February, the GIPS hardware and software were delivered to the 480th IG at Langley AFB. As part of the setup, ERIM and 480th IG personnel verified receipt of the boxes and their contents against the Installation Plan shipping list. All items were delivered except for one box containing a Sparc 20 keyboard. The shipper of the GIPS equipment was notified of the missing box. The shipper located the missing box and delivered it to the 480th IG by 8 a.m. on 22 February.

The GIPS was set up and installed in about three hours. The 480th IG personnel participated in all aspects of the activity. They unpacked boxes, moved equipment, connected cables, brought up the systems, and located a replacement for the missing Sparc 20 keyboard.

3.4.2 Lessons Learned

The success of the shipping and installation activity resulted from having an installation plan, performing a trial pack and installation exercise, and the participation of the 480th IG.

To our surprise, the cost of shipping the system via air freight was comparable to that of truck freight.

3.5 UPGRADE OF THE SUN 670 TO SOLARIS 2.3

3.5.1 Description

At the end of March, we upgraded the operating system of the 480th IG Sun 670 computer. The activity included preparation, travel, and three days of on-site work. John Stelyn of the 480th assisted ERIM personnel in the upgrade. The operating system was upgraded from Sun OS 4.1 to Solaris 2.3. In order to accomplish the operating system upgrade, the Sun 670 hardware also had to be upgraded. This task was to have been performed and completed by the Government.

3.5.2 Lessons Learned

The upgrade of the Sun 670 was originally scheduled to occur prior to the installation of the other three systems in order to meet the arbitrary contractual requirements of an overall six-month project. The original plan would have left the 480th IG without a ADRI production capability for six weeks.

4.0 SOFTWARE ENGINEERING

4.1 DESCRIPTION

The GIPS was configured on four workstations. The software suite selected consists of COTS components along with nondevelopmental items. The COTS software includes ORACLE, ARC/INFO, Motif, SPARCworks, SPARCworks C compiler, and ERIM's proprietary ERIPS (ERIM Remotely-Sensed Image Processing System) package. The nondevelopmental items include the ADRI-specific software modules and the ADRI Production Database System.

An ERIPS Basic License was provided on the 480th IG's existing Sun 670. Three ERIPS Full Licenses were provided on the other three workstations.

Whenever possible, COTS components were used in the system. Their use decreased the overall cost and improved reliability of the overall system.

4.2 ERIPS

4.2.1 Description

ERIPS Version 3.0 was installed on the system. This version runs under the Solaris 2.3 operating system. The ERIPS software was delivered to the Government in the form of object code only. Twelve months of Maintenance and Support are provided with each ERIPS license. The licenses commenced upon acceptance of the GIPS by the Government. After the 12-month period, an annual maintenance contract will be required for continuation of the ERIPS support services.

The ERIPS geocoding modules are used for the precise geometric correction, orthorectification, and mosaicking of imagery. Specific functions performed by these modules include:

- Ingest of SPOT Level 1A data,
- Ingest of Defense Mapping Agency (DMA) Level 1 DTED,
- Point selection and block adjustment of SPOT imagery,
- Orthorectification of SPOT imagery,
- Radiometric balancing of SPOT imagery, and
- Mosaicking of SPOT imagery.

The mosaicking tool within ERIPS permits updating of ADRI ZDRs that have been previously published. An entire SPOT scene or a piece of a SPOT scene can be radiometrically balanced and inserted into an existing ZDR. The Source Map produced by the ERIPS mosaicking module can be used to compile a new ADRI Overview Image as well. (Where Source Maps are unavailable for previously published ZDRs, a procedure will be developed that will allow updating of the Overview Image of a previously published ZDR with only minor visual artifacts.)

The ERIPS basic modules include those modules required for preprocessing the SPOT imagery, including the display server, as well as data loading, histogramming, and deglitching functionality.

4.2.2 Lessons Learned

This effort went as expected.

4.3 MISCELLANEOUS SOFTWARE

4.3.1 Description

The following miscellaneous software licenses were provided with the system: ORACLE, ARC/INFO, Motif, SPARCworks and SPARCworks C compiler. They were procured by Synectics Corporation.

4.3.2 Lessons Learned

The original purchase orders of the software licenses should have included provisions for their transfer to the Air Force. This would have avoided the additional paperwork and effort that was required to transfer the licenses after the delivery of the system.

4.4 ADRI SOFTWARE MODIFICATIONS AND PORT TO SOLARIS 2.3

4.4.1 Description

The non-ERIPS ADRI-specific software modules were modified and configured as required for the Solaris 2.3 operating system and GIPS hardware system. The functions provided by these modules include creation of the ADRI Overview Image, accuracy assessment of the ADRI product, formatting of the ADRI product to 8-mm tape in the format specified by the Military Specification, unloading ADRI images from an ADRI Volume, and duplication of SPOT tapes.

We had planned to develop a new module that would read a ground control file generated by the Analytical Point Positioning System (APPS). This functionality was to have been integrated with a function to read ground control files produced by the DMA. However, after the site visit, the USAF determined that due to security restrictions, data could not be electronically removed from the APPS. As a result, these data had to be manually entered by the operator. Consequently, this function was integrated into the ADRI Production Database System.

The port of the ADRI software to Solaris 2.3 was completed with no major problems. Later, during the function testing, a number of problems were encountered that were attributed to the porting of the software to Solaris 2.3. In several instances, applications that were ported to Solaris 2.3 without any modifications were found to be only partially functioning under Solaris 2.3. This resulted in additional effort to identify and correct the problems, followed by retesting of the applications.

4.4.2 Lessons Learned

Problems due to porting to the Solaris 2.3 were encountered late during the function testing. Testing in parallel of many of the modules compounded the cost of detecting the problems during the function testing. If the problem had been detected early on in one module, it could have been corrected in most of the modules prior to their first testing. This would have eliminated the effort that was required to retest many of the modules.

4.5 DATABASE MODIFICATIONS AND PORT TO SOLARIS 2.3

4.5.1 Description

The ADRI Production Database System is used to track ADRI production and to generate a catalog of ADRI products. It is composed of COTS software packages and nondevelopmental software modules including:

- Database system (ORACLE),
- Plotting software (ARC/INFO), and
- ADRI production management tools.

This activity included a requirements review at ERIM in Ann Arbor on 20 October 1995, which was attended by Jim Sieffert of RL/IRRP. The discussions covered the ADRI database and the data that would be included in the database as part of the delivery. It was particularly important to determine the role that the ADRI database would play in the generation of an ADRI catalog.

The requirements included porting the system and support utilities to Solaris 2.3, adding a capability to load SPOT metadata into the database from CD-ROM, porting from the VAX the capability to load DTED metadata into the database from tape or CD-ROM, modifying the database for a new ZDR Unique Key, supporting the entry and export of ground control point (GCP) metadata into the database, providing support for the exchange of GCP data with DMA, and adding additional database fields in support of anticipated catalog requirements.

The ADRI Production Database System was installed on a GIPS 20a. We had planned to install it on the 480th IG's Sun 670. However, it was installed on the GIPS 20a when it was recognized that the Sun 670 would not be upgraded until after the three new systems were operational.

The ADRI Production Database System was tailored as required for the 480th IG. It was also ported to the Solaris 2.3 operating system.

The port of the ADRI Production Database System to the Solaris 2.3 version of ORACLE V6 RDMS with V3 SQL*FORMS encountered significant technical problems and took longer than planned. The original approach, based on ORACLE's recommendation, was to port the database to ORACLE V7 RDMS with V3 SQL*FORMS. After the port had begun, ERIM discovered that ORACLE V7 RDMS with V3 SQL*FORMS did not support Motif forms as stated. Once this was discovered, ERIM sought ORACLE's assistance to resolve the problem. The assistance provided by ORACLE's sales and technical staff proved to be contradictory and erroneous and further compounded the problem. The resulting technical solution to the ORACLE port problem was to abandon the use of Motif forms and use character-based forms. Unfortunately, this resulted in unplanned effort and the loss of two weeks in the schedule.

4.5.2 Lessons Learned

The lesson learned is that the use of COTS software will decrease the overall cost and reliability of a system, but it is not without some cost or risk.

5.0 TESTING AND DOCUMENTATION

5.1 CREATE AND EXECUTE TEST PLANS

5.1.1 Description

ERIM's ADRI production staff and engineering staff prepared, reviewed, and approved written test plans. The testing included function testing and an end-to-end system test. The test execution occurred at ERIM. The end-to-end system test took almost two weeks and was completed on 10 February.

5.1.2 Lessons Learned

It is important that the time and effort required to test the system not be underestimated. In addition, the thoroughness and quality of testing could not have been achieved without the use of ERIM's very experienced ADRI production staff.

5.2 CREATE AND EXECUTE AN ON-SITE ACCEPTANCE TEST PLAN

5.2.1 Description

ERIM prepared and executed an on-site Acceptance Test Plan after delivery of the GIPS at Langley AFB. The acceptance test was successfully completed on 22 February. It took one and a half days and was witnessed by Jim Sieffert of RL/IRRP and Karen Himes and Kim Vaughn of the 480th IG.

Prior to packing the system, the acceptance test was executed on the system at ERIM. As it was performed after the completion of the system test, it verified that any last minute problems detected during the system test had been properly corrected. Furthermore, this exercise decreased the amount of time it took to perform the actual on-site test, would have isolated any problems (none occurred) that could have been introduced due to the shipment of the equipment or due to the site installation, and helped minimize the simple human mistakes that occur under the pressure of an on-site acceptance test.

To underscore the benefits of the trial acceptance test at ERIM, it is necessary to mention a human error that did occur. During the test an operator used DTED data from an obsolete CD-ROM. There were no external physical markings or labels on either the DTED CD-ROM or the plastic CD-ROM case that would have distinguished the revised and obsolete CD-ROM. On-site this would have been a very difficult problem to resolve.

5.2.2 Lessons Learned

The acceptance test was a small but significant activity that contributed to the overall success of the project. In addition, executing the acceptance test at ERIM reduced the possibility of simple human mistakes occurring during the acceptance test at Langley.

5.3 DOCUMENTATION

5.3.1 Description

ERIM updated, modified, or acquired the necessary user's documentation for the GIPS. All user's documentation was submitted in draft form for Government review. Table 3 identifies the documentation supplied by ERIM. The COTS hardware and software documentation was procured by Synectics and is not included in the table (with the exception of the ERIPS COTS documentation). The documentation was reviewed as part of the execution of the function tests and the end-to-end system test.

Table 3. Documentation Supplied by ERIM

Document
ERIPS User's Guide
ADRI Production Support System User's Guide
ADRI Production Database System User's Guide
ADRI Production Procedures
ADRI Quality Assurance Manual
ADRI Orientation Documentation
GIPS Acceptance Test Plan
GIPS Installation Plan
GIPS Interface Requirements Specification

5.3.2 Lessons Learned

Having the operators review the documentation that applies to what they are testing proved to be a very effective method for validating the documentation. The most thorough review of the documentation occurred during the operator training that was part of the follow-on project.

6.0 MANAGEMENT

6.1 PROGRAM MANAGEMENT

ERIM managed all aspects of the GIPS implementation. The project was completed within two weeks of schedule and slightly over budget.

The activities that took significantly more time and effort than had been planned included the ORACLE port, the Solaris 2.3 port, and function testing. These were offset by activities that took less time and effort than had been planned: documentation, packing and shipping, system installation, and the execution of the on-site acceptance test. Additional savings resulted from not having to integrate the Alden printer.

We did perform one activity at the Government's request that was to have been performed by the Government: upgrading the operating system of the 480th IG's Sun 670 computer.

ERIM conducted the necessary quality assurance actions and inspections to ensure that the GIPS met the design specifications and requirements established for the project. This included final inspections of the installed GIPS hardware and a final hardware and documentation inventory.

6.2 PROGRAM REVIEWS

6.2.1 Description

Two program reviews were conducted during the project. The first program review was held at ERIM in Ann Arbor on 14 through 16 November. Attending the review were Jim Sieffert of RL/IRRP; Fred Aronson of HQ ACC/SMO-P (BETAC); Arliss S. Perry of NAIC/DXHT; Bill Carlton, Craig C. Scheuern, John Stelyn, Karen Himes, and Kevin Koppenhaver from the 480th IG; and Neil Sunderland and Dwayne Willis from the 497th IG.

The November program review included an overview of the ADRI production process, an overview of the program, a review and update of the schedule and deliverables, an overview and status of the ADRI Production Software and Production Database System, the review and status of the GIPS hardware, and the review and status of Government-furnished equipment and activities.

The second program review was held at ERIM in Ann Arbor on 23 and 24 January. Those attending included Jim Sieffert of RL/IRRP; Fred Aronson of HQ ACC/DR-SMO-P (BETAC); Don Batkins of MITRE (ESC/ICI); Bill Carlton, Ramona Montgomery, and John Stelyn from the 480th IG; Neil Sunderland and Dwayne Willis from the 497th IG; and Alan Szynski from the 32 AIS/USAFE.

The January program review included an overview of the program, a review and update of the schedule and deliverables, an overview and status of the ADRI Production Software and Production Database System, the review and status of the documentation and testing tasks, the review and status of the GIPS hardware, the review and status of Government-furnished equipment and activities, and the review and status of action items from the November 1994 program review.

6.2.2 Lessons Learned

Neither program review took the two hours called out in the Government's original Statement of Work (SOW). This additional unplanned effort was partially offset by holding the reviews in Ann Arbor.

6.3 MONTHLY STATUS REPORTS

6.3.1 Description

ERIM prepared and electronically submitted monthly status report via the Internet. Two of the reports were not submitted on time.

6.3.2 Lessons Learned

Electronic submission of monthly status reports is very convenient, quick, and efficient. Monthly status reports must be submitted on time.

7.0 POTENTIAL PROCESS IMPROVEMENTS AND PROCEDURAL ADJUSTMENTS

ERIM evaluated GIPS process improvements and procedural adjustments that the 480th IG could implement within the existing GIPS environment to accelerate the end-to-end production time line. ERIM examined improvements and/or adjustments that either (1) maintain the current quality of the ADRI product or (2) effect a minimal reduction in the quality of the ADRI product. We did not examine algorithmic or hardware changes that ERIM or the 480th IG might make to accelerate production.

7.1 IMPROVEMENTS WITHOUT PRODUCT QUALITY DEGRADATION

This section addresses the activity specified by the SOW 4.1.1.11, which called for the final report to identify and document potential process improvements that would reduce the time required to process each image without degrading the quality of the overall product.

We have identified several potential process improvements. These include making use of a Digital Chip Library, postponing entries into the ADRI Database, postponing SPOT computer compatible tape (CCT) archival, and eliminating the temporary storage of SPOT scenes and final ZDRs on EODs.

The Digital Chip Library provides functions to organize, maintain, retrieve, and display image control points. For areas that ADRI producers have previously controlled, the Digital Chip Library will speed both the selection and mensuration of control points in new imagery because the operator will not need to search the imagery and control source for candidate points. Without the Digital Chip Library to organize previously selected ground control points, ERIM estimates that it may be easier and quicker to derive new points using the APPS rather than attempting to recover uncatalogued digital image chips. Image control point selection and subsequent control derivation on the APPS require approximately 30 minutes per point. The same operations using the Digital Chip Library will take less than 5 minutes per point. (Note: ERIM will deliver the Digital Chip Library to the 480th IG in July 1995.)

The 480th could delay several entries to the ADRI Database in a contingency exercise, and enter them at a later time. The possible consequence is that operators may forget to update the database later. However, the ADRI Database steps that cannot be postponed are the following: (1) Load GIU, (2) GIPSPlot, (3) Define and Update ZDR, (4) Create Map Control Point (MCP) File, (5) Planning Report, (6) Define Volume, and (7) Create Volume Interface File. Only performing these essential steps may save 15 minutes per geo-image unit (GIU).

The 480th also could delay the duping of a SPOT CCT for archival backup in a contingency exercise, and could perform that function at a later time. This will save 5 minutes per GIU.

In addition, the 480th could eliminate copying SPOT scenes and final ZDRs to EODs for temporary storage in a contingency exercise if sufficient disk space was available. On the average (four SPOT scenes per ZDR), this will save approximately 10 minutes per ZDR.

7.2 IMPROVEMENTS WITH ACCEPTABLE QUALITY DEGRADATION

This section addresses the activity specified by SOW 4.1.1.12, which states that the final report is to identify and document potential process improvements and procedural adjustments that could be applied to increase system throughput with an acceptable reduction in output product quality.

We have identified several potential process improvements. These include omitting the review of SPOT data for quality assurance and bad line repair, eliminating the histogramming and interactive

radiometric balancing of a GIU, resampling the SPOT data with a computationally faster kernel, and generating an Overview Image without annotation or mosaic lines.

The 480th IG could skip the review of the SPOT data for quality assurance and bad line repair in a contingency exercise. The final product may have image "hits" in it, but this procedural adjustment may save from 15 to 30 minutes per GIU.

The 480th IG could eliminate the histogramming and interactive radiometric balancing of a GIU (to other GIUs) in a contingency situation. Rather, the 480th could simply normalize each GIU using the sun angle and absolute calibration information presented in the Planning Report. For same-season imagery, this will generally produce an acceptable product. However, the 480th IG should properly balance and republish the product as soon as possible.

The resampling of SPOT images could be performed with a different resampling kernel. SPOT images are resampled in the GIPS ADRI process with a deconvolution resampling kernel to preserve the geometric and radiometric fidelity of the acquired scene radiance. This resampling technique recognizes that the scene radiance has been convolved by the point spread function of the SPOT High Resolution Visual (HRV) scanners. The intent of this approach is to deconvolve the image data by using a priori knowledge of the characteristics of the SPOT HRV to develop a set of processing coefficients which, when multiplied by an array of input SPOT data values, will yield the best estimate of the original scene radiance. The GIPS could use other resampling kernels, such as a bilinear interpolation kernel, albeit with a subsequent loss of fidelity in the final product. However, a resampling run using a bilinear resampling kernel will run approximately in two-thirds the time of a deconvolution resampling run because of the smaller number of resampling calculations (the bilinear kernel looks at 4 input pixels, whereas the deconvolution kernel looks at 16 input pixels). Using a bilinear resampling kernel will save approximately 10 minutes per GIU.

The 480th also could change the Write_Overview procedure to allow the 480th to create the Overview Image without annotation or mosaic lines. As the software does not need to read the Source_Map under this scenario, this procedural change may save up to 10 minutes per ZDR.

8.0 FOLLOW-ON ACTIONS

As follow-on actions, we recommend that the Government continue hardware maintenance; software maintenance for ARC/INFO, ORACLE, and ERIPS; and ADRI Production and Software Support.

9.0 REFERENCES

Electronic Systems Center, Military Specification Broad Area ARC Digital Raster Imagery (ADRI) Product, MIL-B-89031, 24 July 1992.

Electronic Systems Center, Military Specification ARC Digital Raster Imagery (ADRI) Format, MIL-A-89027, 24 July 1992.

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